.

# READING-TO-LEARN AND WRITING-TO-LEARN SCIENCE ACTIVITIES FOR THE ELEMENTARY SCHOOL CLASSROOM


Larry D. Yore, University of Victoria

James A. Shymansky, University of Iowa

Laura Henriques, California State University

Jennifer L. Chidsey, University of Iowa

JoAnne O. Lewis, University of Iowa


## Introduction

Many elementary school teachers realize that more and more hands-on activities is not the solution to unsatisfactory science literacy. The process-product debate of the 1960s reform in which alphabet science programs exclusively promoted hands-on concrete discovery activities was not successful for about 75% of elementary school teachers. The uncertainty of unstructured explorations, the discount of language in favor of sensory experiences, and the complex logistics of manipulatives and small groups stressed the culture of the generalist elementary teachers and their classroom environments.

Today, systemic reforms like Science -- Parents, Activities and Literature (Science PALs) in the Iowa City Community School District are attempting to implement science as inquiry focused on science literacy in a much more user-friendly fashion. Science literacy involves the abilities and dispositions to construct understanding; big ideas, values and informed opinions; and the communication strategies to inform and persuade others. Science PALs uses children's literature as assessment platforms and as springboards for inquiry. Furthermore, numerous connections have been made among science and the language arts.

This paper provides a theoretical framework for reading-to-learn science and writing-to-learn science; outlines applications of language arts approaches, explicit reading strategies and writing genre that enhance science learning; and describes some of the promising uses of these approaches for elementary school science teacher education. Each of these components is anchored in the National Research Council's National Science Education Standards (NRC, 1996) for teaching science, content, and professional development.

## Theoretical Framework

Constructivist approaches emphasize the importance of prior knowledge, concurrent experiences, multiple information sources, social negotiations of meaning and integration of new understandings and existing knowledge networks (Shymansky, 1994). Clearly the sensory experiences and the oral language arts (talking and listening to science) are well accepted by contemporary science education (Lemke, 1990). Only recently have science educators begun to address the value of the print-based language (Santa & Alvermann, 1991; Yore, Holliday & Alvermann, 1994). This recognition in part is based on the realization that the elementary school classroom is a teaching-learning culture that emphasizes language arts, mathematics and social development and that the implementation of the current reforms needs to be anchored in a crosscurricular foundation and requires the enhancement of effective practices.

"My students can't read information books!" No where is this long-expressed cry more frequently heard than in upper elementary grades, when the emphasis clearly shifts from "learning to read" to "reading to learn." Likewise, the value of writing a list to consolidate understanding and to improve memory and the use of webbing to illustrate hidden connections and internal organization of information are well accepted in the elementary school culture. Unfortunately, the relationships between the print-based language arts and science achievement are not well established, but the available "research does not support the concocted claims that reading and writing in science naturally inhibit students' creativity, curiosity, and interest" (Holliday, 1992, p. 60). The major problem facing teacher educators is to convince prospective teachers and practicing teachers of the potential value of science reading and science writing when they have not had any experience with the integration of language arts and science and when much of the science education literature has maligned the importance of reading and writing in science classrooms while exclusively extolling the value of hands-on activities.

## Reading-to-Learn Science

A teacher's knowledge about science text and science reading frequently determines whether or not print materials are used effectively. Many teachers fail to recognize the unique differences between narrative and expository text and cling to the traditional notions that meaning resides solely in the text and that readers simply extract the meaning. They unknowingly design instruction involving science as if science texts were narrative rather than expository and as if reading was a meaning- taking process rather than a meaning-making process (Digisi & Willett, 1995; Gottfried & Kyle, 1992; Shymansky, Yore & Good, 1991).

Science text, unlike the familiar content and predictable story grammar of children's literature, contains unfamiliar content and text structures, heavy conceptual demands, and unique vocabulary. The purpose of scientific text is to assist uninformed and misinformed readers construct meaning about specific science ideas using an expository approach, words (concept labels) with specific meanings, complex and interconnected sentences, and specific text structures (description, collection, compare/contrast, problem/solution, causation).

Reading is not simply a uni-dimensional bottom-up or top-down process involving printed symbols. Rather, reading is an interactive-constructive process that involves making meaning by negotiating understanding between the text and the reader's concurrent experiences and memories of the topic within a sociocultural context (Yore & Shymansky, 1991). The interactive-constructive model of science reading recognizes the importance of prior knowledge, strategies, metacognition (awareness and executive control of meaning making), and sociocultural context.

The interactive-constructive model discounts the beliefs that expert readers differ from novice readers simply in the number of decoding skills acquired or that meaning is simply embedded in the text. An efficient, successful science reader is a strategic person who is aware of, flexible, and manages several sources of information, science text, meaning making and the selection, use, and substitution of several strategies (Craig & Yore, 1995). Flood (1986) metaphorically described the role of printed language in the construction of understanding as the way a contractor uses blueprints in the construction of a building. Flood stated:

Texts establish broad limits of possible meanings, but they do not specify a single meaning. Readers (not texts) create meaning through negotiations with authors. (p. 784)

Readers progressively resolve conflicting meanings involving text-based interpretations extracted from print, recalled ideas from the reader's memory, and shared ideas from the sociocultural context (Craig & Yore, 1996). The reader's recollections might involve different types of knowledge: topic, language structures, science text, and scientif~c enterprise (Alexander & Kulikowich, 1994). Sociocultural context includes the values, beliefs, opinions, and attitudes inherent in the learning environment.

How readers construct understanding appears to be influenced by the readers' prior knowledge, metacognitive awareness, executive control, and access to information rather than the source of information.

To comprehend what we are taught verbally, or what we read, or what we find out by watching a demonstration or doing an experiment, we must invent a model or explanation for it that organizes the information selected from the experience in a way that makes sense to us, that fits our logic or real world experiences, or both. (Osborne & Wittrock, 1983, p. 493)

"Knowledge use and control are at the heart of the knowledge-construction process through purpose setting, planning and organizing, and constructing meaning" (Ruddell & Unrau, 1994, p. 1022).

Expert science readers have metacognitive knowledge about science reading, science text, and specific science reading strategies. Several strategies critical to constructing meaning have been identified; they are frequently absent in ineffective readers but respond to instruction (Dole, Duffy, Rochler & Pearson, 1991; Pressley, Johnson, Symons, McGoldrick & Kurita, 1989). They include:

1. Assessing the importance of text-based information and prior knowledge.

2. Generalizing questions to set purpose.

3. Summarizing.

4. Inferring meaning.

5. Monitoring comprehension.

6. Utilizing text structure.

7. Reading and reasoning critically.

8. Improving memory.

9. Self-regulating to fix-up comprehension failures.

10. Skimming, elaborating, and sequencing.

Older and better readers conceptualize reading and these strategies differently from younger and less able readers. Baker (1991) pointed out that able readers recognize that reading is about understanding and that strategies change to match purpose, utilize various standards to evaluate comprehension, and apply different strategies to fix-up comprehension failures. Effective readers have knowledge about the reading process and personally regulate their purpose, effort, and approach while they are reading.

Explicit instruction on science reading strategies improves metacognitive awareness, reading comprehension, and science achievement (Holder, 1996; Spence, 1994). If it is to be successful, explicit instruction must address all parts of metacognition. Jacobs and Paris (1987) subdivided the metacognitive knowledge (self-appraisal) into declarative knowledge (what), procedural knowledge (how), and conditional knowledge (why and when). They subdivided control (self-management) into strategic planning, monitoring progress, and self-regulation. Pearson and Dole (1987) provided guidelines for effective comprehension instruction that develops metacognitive awareness and transfers knowledge into action. They suggest explicit instruction needs to be embedded in a natural context setting and that instruction should systematically establish need, model desired outcome, provide direct practice and consolidation, and encourage transfer of ownership and application.

## Writing-to Learn-Science

"Writing-to-learn involves and emphasizes the powerful role language plays in the production, as well as the presentation of knowledge" (Connolly, 1989 p. 2). This rhetoric promotes constructivist perspectives of learning by illustrating that the symbol systems used to communicate also play a critical role in constructing meaning and by reflecting the unique way scientists communicate ideas within the scientific community. Science writing involves adopting appropriate rhetorical stances, text structures, and genres that accurately reflect scientific assumptions such as the need for repeatability, verifiability, generalizability, and patterns of argumentation (evidence, warrants, claims).

Halliday (1993) cautioned about over-emphasizing the interpretive nature of scientific language, disregarding the unique structure-function relationship of writing, and assuming that creative and narrative writing will improve science understanding. In order to enhance science learning and improve communication with the science community discipline-specific expository and personal writing tasks must match the inquiry nature of science, the evaluative view of knowledge, and the target learning outcomes. Unfortunately, "we must persuade a group of teachers who themselves did not learn science . . . this way, that writing-to-learn is not only useful but essential for a certain type of student" (Tobias, 1989, p. 48).

Newell and Winograd (1989) stated that "there is at present only slender empirical base from which to conceptualize how writing may aid learning about the topic, that is, how the writing process and what writers take from writing are interrelated" (p. 196). However, writing science appears to clarify fuzzy thinking and enhance understanding (Fellows, 1994; Keys, 1994; Rivard, 1996). Writing makes abstract ideas permanent and allows them to be publicly analyzed, dispassionately criticized, checked for precision, verified for logic, and tested for content. Although writing is a natural extension of speaking, communicating with an unseen audience represents a significant jump in cognitive demand from face-to-face speaking with and listening to someone (Vygotsky, 1978).

Teachers need to help students move from the predominant knowledge-telling writing, which involves converting knowledge from long-term memory into written words essentially unaltered, to a knowledge-transforming approach in which knowledge is actively reworked to improve understanding—"reflected upon, revised, organized, and more richly interconnected" (Scardamalia & Bereiter, 1986, p. 16). The knowledge-transforming model clarifies the role of conceptual knowledge about the target topic and of metacognitive knowledge about discourse, patterns of argumentation, and genre. Utilizing the knowledge-transforming model as an operational framework, teachers would get students to spend more time setting purpose, specifying audience, selecting a purpose-appropriate genre, thinking, negotiating, strategic planning, reacting, reflecting, and revising. Teachers would also provide explicit instruction embedded in the authentic context of "science as inquiry" designed to clarify what writing is; the purpose-specific nature of scientific genre; the interactive, constructive, generative nature of science language; the relationship between evidence, warrants, and claims; and what, how, when, and why to use specific writing strategies. The describe, explain, instruct, and argue genre appear to have the greatest applications to science (Gallagher, Knapp & Noble, 1993).

Description involves personal, commonsense, and technical descriptions, information and scientific reports, and definitions. Frequently descriptions wiU be structured by time-series of events, scientifically established classifications or taxonomies, or accepted reporting pattern of information (5 Ws). Explanation involves sequencing events in temporal or causal relationships. Explanations attempt to link established ideas or models to observed effects by using a logical connective of "if this, then this." Instruction involves logical ordering a sequence of actions to specify a procedure, manual, experiments, recipe, or direction. Instructions can effectively utilize a series of steps short declarative statements—in which the sequence is established by tested science, i.e., pour acid into water before adding zinc. Argumentation involves logical ordering or propositions to persuade someone in an essay, discussion, debate, report, or review. Arguments attempt to establish the boundaries and conditions of the issue and then to systematically discredit, destroy, or support components of the issue to clearly disconfirm or confirm the basic premises.

Howard and Barton (1986) stated the "idea is to learn to think in writing primarily for your own edification and then the eyes of others. This approach will enable you to use writing to become more intelligent to yourself—to find your meaning—as well as to communicate effectively with others" (p. 14). The following principles should guide the development of writing-to-learn tasks in science (Tchudi & Huerta, 1983):

* Keep science content central in the writing process.
* Help students structure and synthesize their knowledge.
* Provide a real audience for student writers that will value, question, and provide supportive criticism.
* Spend time prewriting, collecting information from various sources (concrete experiences, print materials, experts, electronic data banks, visuals, etc.), sharpening focus, and strategic planning.
* Provide on-going teacher support, guidance, and explicit instruction.
* Encourage revisions and redrafts based on supportive criticism to address conceptual questions and clarify understandings.
* Clarify the differences between revising and editing (format, spelling, mechanics, grammar).

Writing in science during the elementary school years has generally been used for evaluation and review purposes but not for emphasizing knowledge construction and critical thinking, and for stressing creative writing but not expository writing. Jan (1993) used implicit and explicit modeling to help students learn about the various ways language is used in science and to have students use print-based language to learn science. She stressed that writing in science "must not be relegated to mere completion of worksheets or to the recipe-type" writing tasks (p. 41). Rather, students need to be engaged in authentic science situations that involve different writing forms for specific purposes and audiences.

Unsworth and Lockhart (1994) explored how junior primary (Grade 2) teachers attempted to integrate print-based language arts into their science classes in two inner-city schools. They found writing (12%, 17%) and reading (15%, 11%) accounted for a minority of the instructional time in the two science classes. The writing involved a variety of tasks: factual, extending text, lists, and diagrams. Unfortunately, little preparatory or explicit instruction, limited to modeling and structured worksheets, was provided for science writing and science reading.

Burkhalter (1995) used an instructional scaffolding dealing with persuasive writing (data, warrants, and claims) with grades 4 and 6 students and found significant pretest-posttest conceptual growth, a significant explicit instruction effect, and a significant gender effect favoring females. She concluded that students as young as nine years can benefit from explicit persuasive writing instruction.

Bergin (1995) explored a combined reading-writing approach to teaching summarizing. She stated:

The cognitive operations involved in summarizing include knowing how to select, condense and transform information. Selecting information involves identifying information which is relevant and important. Condensing involves synthesizing information so that the structurally important information is gleaned; and in order to transform information, students must relate main ideas to each other and reconstruct a meaning which is concise but representative of the original text's structure and content. (p. 30)

These cognitive operations have been demonstrated to be part of an expert scientist's and science learner's repertoire. Bergin found that students improved their ability to select and combine main ideas when the instruction provided an effective framework, active role, and encouraged self regulation and improved skills.

Children's Literature as Assessment Platforms and Springboards for Inquirv

Children's literature such as Goldilocks and the Three Bears, Porker's Taxi, The Hungry Caterpillar and Who Sank the Boat provide excellent platforms and springboards for science. Each of these stories include common misconceptions or interesting problems about thermodynamics, work and energy, life cycles, and buoyancy concepts embedded in a natural context for children.

Science PALs utilizes science-oriented children's literature as the central focus of bookbags designed to engage parents and children in an assessment of prior knowledge. The book serves as an assessment platform and a structured interview protocol consisting of 4 to 7 questions guides the parent-child discussion. The discussions are enriched by hands-on activities that have minimal equipment requirements included in the bookbag.

Parent involvement is often cited as the single best way to improve student achievement and interest in school. Consistent evidence exists to show that parent encouragement, activities and interest at home and parent participation at school affect children's achievement even after the student's ability and family socioeconomic status is taken into account. Students learn best when parents actively monitor and support their school work. In addition, students benefit from the interactions with parents and guardians provided by the hands-on science experiences, together with conversations about what is occurring.

Making parents productive partners in education benefits teachers, as well as parents and students. Science PALs teachers value parent involvement in school in both instructional and noninstructional capacities and frequently have the opportunity to communicate with parents about students and school events. Through involvement with school, parents gain first-hand information about what their child is experiencing and learning and become strong advocates for school and collaborative problem-solvers when needed.

Therefore, asking parents to play a role in gathering information about students' ideas will be viewed as important by all involved, but this task needs to provide opportunities the are welcomed by both participants and that are useful to the teacher in order to be most effective. Requirements for the parents must take into account time constraints on the part of the parent/care giver and the teacher must be able to easily convey the purpose and expectations associated with the task to the parent. The Science PALs project has created opportunities for parent involvement that address these needs and are extremely well-received by parents and students. The purpose of collecting student information does more than give parents and children a chance to interact about what is happening at school. The information collected and reported are necessary resources for the constructivist teacher (Chidsey & Henriques, 1996).

Science PALs also use children's literature as natural context to initiate science units. Teachers read stories to get students thinking and talking about science ideas and as inquiry springboards for hands-on activities. Frequently a single story will provide numerous challenges for students to explore. Students and teachers can simply replicate the science described in the story or can design experiments or plan library research to verify the science concepts used in the story. Upon completion of the science units, students can return to the literature to critically analyze the embedded concepts and to rewrite the story to achieve scientific accuracy.

## Explicit Science Reading Instruction

Explicit science reading instruction must be embedded in the natural context of effective science instruction, must provide information about why and when, as well as what and how, and must address transfer to other science reading situations (Pressley, El-Dinary, Caskins, Schuler, Bergman, Almasi & Brown, 1992). Effective explicit instruction should be embedded in authentic learning task, teachers should model desired outcome and think-aloud to make metacognition public, and students should be encouraged to do the same and encouraged to take ownership of the strategy. Transfer of ownership and application are consistently the most problematic aspects of strategy instruction, but explicit application of strategies across the curriculum and within a discipline enhances the likelihood of transfer. Furthermore, research results indicate that less able readers (low-reading-ability students and male students) benefit most from such explicit instruction and that explicit strategy instruction improves general science reading comprehension (Spence, 1994). Unfortunately, only a small percentage of elementary school students receives any explicit content reading instruction. It is not surprising that many students find reading science texts difficult and frustrating.

The following strategies address six areas of science reading comprehension that respond to strategic instruction: using surface features, prior knowledge, defining from context, identifying main ideas, summarizing, and recognizing text structures (Spence, 1994).

## Surface Structure and Organization

The layout of the text, the titles of the sections, the diagrams, pictures and charts, and the questions posed in the text are surface features and organizational clues that aid readers' comprehension. These clues provide an overview of what the text is about and what some of the subtopics may be. Considerate science text provides consistent layout, logical topic development, and pictures, graphs, tables, and illustrations to enhance the meaning constructed from the printed message. Visual adjuncts are anchored in the print and are clearly labelled to enhance clarity and connectedness. Effective science text provides advance organization of units and chapters and provides concrete experience with a topic prior to most reading activities.

## Prior Knowledge

Establishing experiential background and accessing prior knowledge are critical in the improvement of science reading comprehension. The abstract nature of science texts dictates that scientific materials are not to be read in isolation from other experiences and supportive activities. A simple guiding principle is "do first, read later." Traditionally, teachers and textbooks reserve concrete explorations until after students have read the text. This approach is justified for classroom management reasons, but it prevents the experiences from being utilized by students to facilitate comprehension and enrich meaning. Furthermore, this sequence relegates the explorations to verificational inquiries or cookbook activities that simply confirm what the text has stated. Reading concept-rich science material in elementary school should be utilized to confirm, reinforce, and enrich concepts partially developed by concrete inquiries and supplemented by peer pair, cooperative group, or whole class discussions.

One way to access prior knowledge, set purpose, monitor progress, and improve science reading comprehension is to use the K-W-L approach, which utilizes a three-column chart to facilitate text processing (Ogle, 1986). K-W-L charts systematically require students to establish what they know (K) about a topic, to set what they want to know (W), and to monitor what they have learned (L). The K-W-L approach is closely aligned with the metacognitive dimension of the interactive-constructive model's accessing prior knowledge, setting purpose, and monitoring progress. Classroom application of the K-W-L technique might involve brainstorming to list what is already known (K) about the topic and to elicit questions that reflect what students want (W) to know about the topic. Teachers must be careful to suspend judgment of student ideas during the initial discussions, to provide questions pertinent to the reading, and to elicit student generated questions that maximize the students' ownership of the process. After reading the text, both scientific or issues-related discussions should help students engage prior knowledge, address contradictions, and construct new understandings, composed of either revised or new conceptions. These results are entered in the third column of the K-W-L chart. Comparing the entries in all three columns allows both the teacher and the students to clearly monitor learning (L).

## Using Context

Science text is composed of unique word labels for conceptual clusters of scientific experiences that are uncommon in non-science text, and these word meanings reflect specific situational context. Effective readers frequently make decisions about word meanings based on contextual clues provided within the word, sentence, and passage surrounding the target word. The use of prefixes, suffixes, and root-words; the use of metaphors and analogies; the use of specific signal words and logical connectives; and the use of general text meaning are component skills involved in the defining from context strategy.

## Identifying Main Ideas

Students who receive explicit instruction on identifying main ideas demonstrate improved comprehension (Dole, Duffy, Roehler & Pearson 1991). Paris (1987) utilized a "detective" metaphor (a reasonable metaphor for a scientist) in which the reader uses clues like pictures, topic, and title to find the main idea He pointed out that many readers mistakenly believe the main idea is always described in the first or last sentence of the paragraph; unfortunately, science paragraphs do not always contain traditional topic sentences. Effective science readers must use a variety of relevant clues to identify main ideas or to even generate their own when none is given. The following lesson plan illustrates how elementary students might be taught about main ideas in the science classroom (Figure 1). Title, subheadings, bold-print, margin notes, pictures, in-text questions, topical context, and other print and layout features can be used as clues to imply main ideas. The actual clue used may vary from text to text.

## Summarization

Ineffective readers tend not to differentiate amongst information and often "tell all" when asked to summarize. This weakness may be apparent in these students' class notes and highlighted textbooks; notes resemble verbatim minutes and textbook pages look like fields of dandelions. Explicit instruction on selecting important information, deleting that which is less important, trivial or redundant, and synthesizing the retained information into an integrated, coherent, and accurate representation improves comprehension (Dole, et al, 1991).

With slight modifications of Paris' (1987) "western round-up" metaphor, readers' attention can be refocussed from the S W's for current events to main ideas, applications, evidence and exceptions for generating science text summaries. Other metaphors can be developed to capture regional differences and student's interests, such as seine fishing, etc. Macro-rules can be established to get students to identify important main ideas, to delete unnecessary details and identify critical evidence and examples/counter-examples, and to generate a concise paragraph or pattern of argumentation that retains the author's intent. The following example demonstrates a practical application of explicit instruction utilizing a typical science textbook (Figure 2).

## Text Structures

Expository text does not have a single developmental structure like the traditional narrative text's story grammar (setting, beginning, development, ending). Science texts frequently utilize five common

Figure 1

Explicit Instruction about Detecting the Main Ideas

1. Understanding the Metaphor

The teacher, wearing a deerstalker hat, tweed jacket with large magnifying glass, referring to a poster of labeled footprints (pictures, margin notes, titles/ headings, context, prior ideas, actions, in-text questions, outcomes) accompanied by two questions, discusses with the class how clues are used to infer "who done it?" and "what caused it?" A review of how to play Clue £) (Parker Brothers) illustrates how they used evidence to eliminate possibilities and progressively alive at the best option. Attention is then directed toward the metaphor on the poster and the two questions:

1. Did I ask myself questions?

2. Did I use clues to find the main idea?

2. Direct Explanation

Students are asked to explain what is meant by main idea, how the main idea might differ from the topic, and why the main idea is so important. Next, students can be asked if they ever have difficulty finding the main idea. If so, what clues did they use? The students' attention is focused on the labeled footprints on the poster.

3. Guided Practice

The strategy is now applied to a specific passage from the students' textbook. The students are asked to use information from their textbook to complete a footprint hand-out (reduced copy of a poster) directed at finding the main idea.

4. Specific Feedback and Consolidation

The teacher models the process by thinking-aloud as each footprint is considgred.

5. Independent Practice and Transfer of Ownership

The teacher requires students to use this strategy on each of the next four to six science reading assignments.

6. Application

The teacher reminds, encourages, and reinforces the use of this strategy when appropriate. Encouragement is given to students using the strategy.

Figure 2

Explicit Instruction about Summarizing—Rounding-up Ideas

1. Understanding the Metaphor

The teacher, dressed in western hat, jeans, shirt and boots, carrying a lasso, introduces the poster illustrating a round-up of cattle into a corral. A clear differentiation of cows and calves is provided. Calves in the corral are labeled (main idea, evidence, exceptions, applications) while the others are not.

2. Direct Explanation

Discussion of the poster compares a round-up with a summary. Direct questions reveal the fact that calves are rounded-up while yearlings and cows are not. Attention is directed to the labeled calves, and additional labels are added to unlabelled calves in the corral. A rationale for each type of idea to be included in the summary is developed and added to the poster.

3. Guided Practice

The strategy is applied to a specific passage from the students' textbook. The students are asked to read the text and complete a round-up hand-out on summarizing.

4. Specific Feedback and Consolidation

The teacher discusses the type of information and the synthesis process used in composing the summary. A think-aloud approach is used to make the thinking process evident to students.

5. Independent Practice and transfer of Ownership

The teacher requires the students to complete a summary hand-out for the next four to six reading assignments. The actual summaries are entered in the learning journals as a three-sentence summary. The first sentence identifies the main idea. The second sentence provide supportive detail or evidence. The third sentence provide a relevant application of the main idea.

6. Application Cooperative review groups are established to identify main ideas, evidence, and applications of each lesson. These ideas are summarized in the students' journals.

Figure 3

Explicit Instruction about Cause/Effect Text Structure

1. Understanding the Metaphor

The teacher, dressed in jeans, work shirt, boots and hard hat, carrying a roll of blueprints, addresses the poster of a bridge entitled function and structure. The students are asked to identify examples of the function-structure relationship in the natural environment and the people-built environment. The discussion explores how the construction worker uses function structure relationships. The teacher then directs their attention to the function-structure of written materials—stories, news articles, etc.

2. Direct Explanation The teacher introduces the use of function-structure relationship in scientific writing. The scientific journal format--purpose, problem, hypothesis, material, procedure, data, analysis, and conclusion— is discussed. The teacher points out that this standard reporting format does not accurately reflect how scientists solve problems but it does provide a consistent format for journal readers. The teacher introduces the five common functions and structures used in scientific writing:

a Reporting observations and measurements description.

b. Reporting characteristics—collection.

c. Reporting likes/dislikes of two or more ideas—compare/ contrast.

d. Reporting cause-effect relationships—causation.

e. Reporting problem-solving—problem-solution.

Overhead transparencies of the templates for each text structure are projected and discussed The benefits of using these graphic displays for organizing information are discussed.

3. Guided Practice

The cause/effect frame is applied to specific text from the students' textbook. The students are asked to read the passage and complete the template.

4. Specific Feedback and Consolidation

The teacher discusses the completed template and where information was found. The general characteristics of cause/effect text are described: two or more paragraphs sequenced to describe the effect and factors related to the result in a causal relationship.The teacher uses a think-aloud approach to clarify the process for students.

5. Independent Practice and Transfer of Ownership

The cause/effect template is used when text passages are encountered in the science textbook until students are sufficiently confident without it. The cause/effect template is also used as a basis for writing cause/effect passages from data collected during experiments.

6. Application

This text structure and template are used in writing and reading in social studies and in science articles or science tradebooks.

structures: description, collection, compare/contrast, causation, and problem-solution. Each structure has its own predictable logic and organization. Unfortunately these text structures differ slightly from the writing genre discussed in writing to learn. Effective readers are able to identify these text structures and to use the knowledge of these structures to improve comprehension. Armbruster (1991) reported that instruction on these text structures improves reading comprehension. Armbruster, Anderson, and Ostertag (1989) described how to use specific templates to assist readers develop proficiency with various text structures and improve comprehension. The following example applies this approach to a cause/effect textual passage (Figure 3).

## Explicit Science Writing Instruction

A problem faced by teachers in writing-to-learn science activities is students copying undigested chunks of material that are not understood nor, consequently, remembered. The reason that students copy from their resource books is threefold: (1) the resource material is already in required form; (2) students are reading text written by experts and writing to an informed audience; and (3) the writing is not focused on authentic questions requiring synthesis of ideas into unifying concepts (Anthony, Johnson & Yore, 1996).

Writing a science 'report' usually means an informative, factual expository report. The research information for the science report is normally obtained from one or more resources, most frequently books. The resource books consulted by the students are already framed as informative, factual expositions and a single source contains far more information on the topic than needed or expected. Thus students are faced with a transportation and edit-to-length problem rather and a transformation, interpretative, and synthesis problem.

The problem is compounded by the fact that both the author of the text and the audience (the teacher) knows more about the topic than the student writers. Thus, students read and write beyond their level of expertise. Novice writers are called upon (a) to read in an area about which they have little concrete experience and know little, (b) to develop expertise, and (c) to write in a form that is used to "inform" someone who may well know more about the topic.

Report writing assignments are frequently topic centered and fact focused. The teacher decides on a broad topic to be addressed, identifies a number of components within the topic, and assigns one component to each student or small group. The teacher may well take the students through a K-W-L sequence but the questions generated are frequently factual rather than strategic. Such low-level questions may be answered with specifics (knowledge telling), therefore the students arrive at the resource material lacking a strategic question that requires them to analyze, synthesize or verify the isolated text-explicit information (knowledge transforming).

One simple way to discourage copying is to separate resources and notebooks and to utilize a variety of resources—concrete experiments, videos, internet, books, pictures, experts, etc. Designating an area of the classroom as the resource centre where a variety of resources are displayed and another area for writing limits the copying problem (Anthony, Johnson & Yore, 1996). The separation rule says: At your desk you may have either a resource book or your notebook but you may not have both. There is no limit on the times resources and notebooks may be exchanged. This system has been used successfully with very young students. One of the first strategies employed by students is "remember one word at a time," but leg fatigue requires them to move on to the "read and understand the ideas" strategy.

The "beyond the level of expertise" problem can be partially solved by having the novices collaboratively research different sources and write to inform their peers. Collaboration in the early information selecting and processing stages encourages novices to share ideas and negotiate meaning with others of equal backgrounds. This procedure becomes exciting when the group encounters discrepant information from different sources that requires them to determine the most valid information or representation. Collaboration helps the group build expertise together. A sharing session in which each group presents their material to the rest of the class provides an authentic audience. An alternative maneuver is to have older children write for younger children. Buddy systems, frequently used to enhance reading, can be modified to provide an authentic audience for young science writers.

The "lack of strategic focus" problem can be solved by the use of radiant questions (Anthony, Johnson & Yore, 1996). A radiant question is one that elicits different but connected answers depending on where one looks for an answer. The adoption of a radiant question makes an enormous psychological difference when the students arrive at their resource books. Resources will present ample material that pertains to their question, but no single resource addresses the total question. The novices must read and write selectively. The radiant question requires the students to be selective, inferential, and critical to find appropriate information and to address discrepant information. Such text-implicit questions require the students to infer, access other information, compare-contrast, analyze, and generalize—the fundamental cognitive processes of science.

## The Information Retrieval Matrix

Writing an informational report is neither a miraculous nor mysterious task. Rather it is simply a matter of making explicit those features of thought and language that are the instructional goals of the assigned task. This example describes the process of instructing a class in the task of writing an informational report about population traits and genetics. The explicit instruction procedure is focused on writing to learn by establishing an information retrieval matrix to support the interpretation of information, explicitly modeling the conventions of writing in science, guided practice of the approach, and independent application of the procedure to generate a descriptive, instructive, explanative, or argumentative report.

A writing-to -learn science experience designed to introduce different genre can be illustrated by using an information retrieval matrix (columns for questions and rows for information sources) to establish strategic questions and collect information about population variation in traits, reproduction, heredity, chromosomes, genes, dominant traits, recessive traits, and patterns of inheritance. A K-W-L chart is used to organize the knowledge and questions about large posters illustrating life cycles and new generations of people, cats, dogs, and roses. Questions naturally arise as the variation in observable traits increase within a group or whether the grouping represents a "biological family," what causes the variation, and why some groupings have very small variations. These types of questions will provide the central foundation for the radiant questions used to set the writing assignments.

After the "K" and "W" are completed, the first concrete inquiry should involve collecting data about the students' observable traits (eye color, hair color, handedness, tongue rolling, widow's peak, detached earlobes, relative length of the pointer and ring fingers, etc.). These data can be graphed for the class to determine most common traits and population variations. The graph can be used to write and illustrate descriptions of the most common or least common student in the class. A "child find" poster could be used as a model for writing a description.

Next, the individual students' traits can be color-coded onto a paper strip divided into a specific number of rows equal to the traits observed representing the genes in a chromosome. The paper strip can be cut longitudinally. One-half of the chromosome can be traded with someone. Additional trades can be made, but half of the student's original chromosomes must be retained. The two halves of the paper chromosomes are taped together to represent the gene pairs of a complete chromosome. The resulting chromosome is then interpreted. Matched pairs of genes clearly result in predictable traits, but unmatched pairs of genes require further exploration. Appropriate text, video, internet, and experts should be consulted to establish dominant and recessive traits and patterns of inheritance.

After the exploration students are randomly assigned a number 1, 2, 3, or 4. The assigned numbers correspond to a specific writing task.

1. Describe your offspring represented by the paper chromosome.

2. Tell someone how to determine the traits of the offspring represented by the

3. Explain why unmatched pairs of genes on the paper chromosome could increase variation in the next generation.

4. Argue why eye, hair and skin colors of the world's population will likely get darker as people mix.

Small groups can be formed out of students assigned the same radiant question (l's, 2's, 3's or 4's). The groups form "expert" groups like a "jig-saw" approach to research, discuss, and write. Collaboration is encouraged, but individual written assignments are expected. The completed writing tasks are shared with peers from the other expert groups and with peers from the other radiant question groups. Whole group discussion should consolidate the scientific understanding and clarify the structural characteristics of each written form used to describe, instruct, explain, and argue.

Promising Applications

Simply increasing the number of hands-on activities in science is not the solution to the science literacy issue. We must selectively infuse other tasks into our science instruction that ensures students' minds are on during these hands-on experiences and that promotes the strategies required of life-long reamers. Tasks that have significant and discernibly positive effects are reading-to-learn strategies (Holder, 1996; Spence, 1994) and writing-to-learn science using appropriate genre (Fellow, 1994; Key, 1994; Rivard, 1996). These tasks encourage students to engage prior knowledge structures, access print-base information systems, construct new ideas, reorganize knowledge structures, integrate new and old knowledge, seek real world applications, and persuade others to take action. We believe that reading-to-learn strategies and writing-to-learn strategies have the benefits of improved conceptual understanding and memory and the benefit of improved communication of these informed perspectives science literacy.

If conceptual change and comprehension are prime objectives of science instruction and if scientific literacy involves a dimension of intellectual liberation, active citizenship, and lifelong learning, then explicit instruction in science reading and writing strategies must be a part of the overall science program. Hynd, Qian, Ridgeway and Pickle (1991) pointed out that both hands-on inquiry and print-based information require suppordve scaffolding to ensure conceptual change. Strategic science reading and writing instruction must keep improved science literacy as its central focus and it should engage prior conceptions, resolve contradictions, facilitate restructuring of understanding, and illustrate real-life applications. Furthermore, strategies instruction should provide students with metacognitive knowledge about using these strategies (WHAT are they? HOW are they used? WHEN should they be used? WHY use them?) as wel1 as executive control dealing with strategic planning, selection, self-monitoring, and regulating effort.

We have found that reading and writing strategy instruction are inter-related, are crossdisciplinary, and are receiving greater attention in the professional journals. The examples included in this paper clearly illustrate the potential of writing to read and reading to write. Analysis of social studies textual materials and mathematical textual materials demonstrates significant similarities among science, social studies, and mathematics text and dissimilarities between any of these and narrative text. The annotated bibliography of recent articles from science education and language education journals illustrates the type of science reading and science writing ideas being promoted (Appendix A). Inclusion of the entries into the annotated bibliography does not indicate unreserved endorsement of each idea since many of these professional articles do not provide adequate research evidence and clear theoretical warrants for their claims. These articles are reasonable resources to use with pre-service and inservice elementary teachers.

The genre that have specific applications in science (description, explanation, instruction, argumentation) are flexible, and the writer must control the specific form to address the function or purpose. If you use templates to introduce these genre, you must explicitly develop the idea that variation in form to address function is appropriate. Armbruster, Anderson, and Ostertag (1989) provide four templates for problem-solution, compare-contrast, sequence, and causeeffect that could be slightly modified to match the genre theory and be used to improve reading comprehension and expository writing.

No lengthy piece of text uses a single genre. Analysis of effective writing illustrates micro-structures embedded within the macro-structure. In argumentation a writer might start with a descriptive passage to engage the reader, later the writer uses an explanation passage to illustrate a critical cause-effect relationship, and in closing the writer may use an instruction passage much the way a judge clarifies the issues, critical evidence, and the charge.

Reflections on recent research indicate that greatest effects of reading and writing to learn occur when the strategies are implemented across the curriculum and not restricted to a single discipline. Spence (1994) found numerous opportunities to apply the expository reading strategies discussed in this paper in social studies, mathematics, and language arts. We believe that a similar impact will be found for science writing strategies as the research foundation increases. Integration of science and language arts have proven dine-efficiencies and improves both science and reading achievement and attitudes (Romance & Vitale, 1992).

## References

Alexander, P.A., & Kulikowich, J.M. (1994). A secondary analysis: Learning from physics text. Journal of Research in Science Teaching, 31, 895-911.

Anthony, R.J., Johnson, T.D. & Yore, L.D. (1996). Write-to-learn science strategies. Catalvst, 39(4), 10-16.

Armbruster, B.B. (1991). Framing: A technique for improving learning from science texts. In C.M. Santa & D.E. Alvermann (Eds.), Science learning: Processes and applications, (pp. 104-113). Newark, DE: Internadonal Reading Association.

Armbruster, B.B., Anderson, T.H., & Ostertag, J. (1989). Teaching text structure to improve reading and writing. Reading Teacher, 43, 130-137.

Baker, L., (1991). Metacognidon, reading and science education. In C.M. Santa & D.E. Alvermann (Eds.) Science learning Processes and application, (pp. 2-13). Newark, NJ: Intern adon al Re ading As sociadon .

Bergin, D.A. (1995). A condnued approach to teaching summarizing. Australian Journal ofLanguage and Literacy, 18, 30-42.

Burkhalter, N. (1995). A Vygotsky-based curriculum for teaching persuasive writing in the elementary grades. Language Arts, 72, 192-199.

Chidsey, J.L. & Henriques, L. (1996). Can parents effecdvely assess their children's ideas about science? Paper present at the 69th Annual Meedug of the Nadonal Association of Research in Science Teaching, St. Louis, MO.

Connolly, P. (1989). Wridug and the ecology of learning. In P. Connolly & T. Vilardi (Eds.), Writing to learn mathematics and science (pp. 1-14). New York, NY: Teachers College Press.

Craig, M.T. & Yore, L.D. (1996). Middle school students' awareness of strategies for resolving comprehension difficuldes in science reading. Journal of Research and Development in Education, 29, 226-238.

Craig, M.T., & Yore, L.D. (1995) Middle school students metacognidve knowledge about science reading and science text: An interview study. Reading Psvchologv, 16, 169-213.

DiGisi, L.L., & Willett, J.B. (1995). What high school biology teachers say about their textbook use: A descripdve study. Journa1 of Research in Science Teaching, 32, 123-142.

Dole, J.A., Duffy, G.G., Roehler, L.R. & Pearson, P.D. (1991). Moving from the old to the new: Research on reading comprehension instrucdon. Review of Education Research, 61, 239264.

Fellows, N.J. (1994). A window into thinking: Using student wridug to understand conceptual change in science learning. Journal of Research in Science Teaching, 31, 9X5-1001.

Flood, J. (1986). The text, the student, and the teacher: Learning from exposition in middle schools. Reading Teacher, 39, 784-791.

Gallagher, M., Knapp, P. & Noble, G. (1993). Genre in pracdce. In B. Cope & M. Kalatzis (Eds.). The power literacy: A genre approach to teaching writing (pp. 179-202). Pittsburgh, PA: University of Pittsburgh Press.

Gottfried, S.S., & Kyle, W.C. (1992). Textbooks use and the biology educadon desired state. Journal of Research in Science Teaching, 29, 35-49.

Halliday, M.A.K. (1993). Language and the order of nature. In M.A.K. HaUiday & J.R. Mardn (Eds.), Writing science: Literacv and discursive power (pp. 106-123). Washington, DC: Falmer Press.

Holden, T. (1996). Relationships among learning styles, metacognition, attitude and science achievement of Grade 6 and 7 students in a guided inquiry explicit strategy instruction context. Unpublished Ph.D. Dissertation, Victoria, BC: University of Victoria

HoUiday, W.G. (1992). Helping coUege science students read and write. Journal of College Science Teaching, 21(1),58-61.

Howard, V.A. & Barton, J.H. (1986). Thinking on paper. New York, NY: QuiU.

Hynd, C.R., Qian, G., Ridgeway, V.G. & Pickle, M. (1991). Promodog conceptual change with science texts and discussion. lournal of Reading, 34, 596-601.

Jacobs, J.E., & Paris, S.G. (1987). Children's metacognidon about reading: Issues of definition, measurement, and instrucdon. Educational Psychologist, 22, 255-278.

Jan, L.W. (1993). Ways of writing science. In J. Scott (Ed.), Science and Language Links -Classroom Implications (pp. 39-50). Portsmouth, NY: Heinemann.

Keys, C.W. (1994). The development of sciendfic reasoning skiUs in conjuncdon with collaboradve wridng assignments: An interpreUve study of six ninth-grade students. Journal of Research in Science Teaching, 31, 1003-1022.

Lemke, J.L. (1990). Talking science: Language learning and values. Norwood, NJ: Ablex.

NeweU, G.E. & Winograd, P. (1989). The effects of writing on learning from expository text. Written Communication, 6, 196-217.

NRC (1996). National science education standards, Washington, DC: National Academy Press

Ogle, D.M., (1986). K-W-L: A teaching model that develops acdve reading of expository text. Reading Teacher, 39, 564-576.

Osborne, R.J. & Wittrock, M.C. (1983). Learning science: A generative process. Science Educadon, 67, 489-508.

Paris, S.G., (1987). Reading and thinking strategies. Lexington, MA: D.C. Heath.

Pearson, P.D. & Dole, J.A. (1987). Explicit comprehension instruction: A review of research and a conceptualization of instrucdon. Elementary School Journal, 88, 151-156.

Pressley, M., El-Dinary, P.B., Gaskins, I., Schuder, T., Bergman, J.L., Almasi, J. & Brown, R. (1992) Beyond direct explanadon: Transacdonal instrucdon of reading comprehension strategies. Elementary School Journal, 92, 513-555.

Pressley, M., Johnson, C.J., Symons, S., McGoldrick, J.A. & Kurita, J.A., (1989). Strategies that improve memory and comprehension of what is read. Elementary School Journal, 90, 332.

Rivard, L.P. (1996). The effects of talking and writing, alone and combined, on learning science: An exploratory study. Unpublished Ph.D. Dissertadon, Winnipeg, MAN: University of Manitoba

Romance, N.R. & Vitale, M.R. (1992). A curriculum strategy that expands time for in-depth elementary science instrucdon by using science-base reading strategies: Effects of a yearlong study in grade four. Journal of Research in Science Teaching, 29, 545-554.

Ruddell, R.B., & Unrau, N.J. (1994). Reading as a meaning-construction process: The reader, the text, and the teacher. In R.B. Ruddell, M.R. Ruddell, & H. Singer (Eds.) Theoretical models and processes of Reading (pp. 996-1056). Newark, DE: Internadonal Reading Associadon.

Santa, C.M. & Alvermann, D.E. (Eds., 1991). Science learning: Processes and applications. Newark, DE: Internadonal Reading Association.

Scardamalia, M. & Bereiter, C. (1986). Helping students become better writers. School Administrator, 42(4), 16 & 26.

Shymansky, J.A. (1994). Interactive-constructive perspective of constructivism. Paper presented at the Annual Meeting of Nadonal Associadon for Research in Science Teaching, San Francisco, CA.

Shymansky, J.A., Yore, L.D., & Good, R. (1991). Elementary school teacher's beliefs about and percephon of elementary school science, science reading, science textbooks, and supportive instrucdonal factors. Journal of Research in Science Teaching, 28, 437-454.

Spence, D.J. (1994). Explicit Science Reading Instruction in Grade 7: Metacognitive awareness, metacognidve self-management and science reading comprehension. Unpublished M.Ed. Project, University of Victoria, Victoria, B.C.

Tchudi, S.N. & Huerta, M.C. (1983). Teaching Writing in the Content Areas: Middle SchooVJunior High. Washington, DC: Nadonal Education Associadon.

Tobias, S. (1989). Wridng to learn science and mathematics. In P. Connolly & T. Vilardi (Eds.), Wridng to learn mathemadcs and science (pp. 48-55). New York, NY: Teachers College Press.

Unsworth, L. & Lockhart, A. (1994). Literacy and learning in science: What's happening in the junior primary school? The Australian Journal of Learning and Literacy, 17(3), 212-225.

Vygotsky, L.S. (1978). Thought and language. Cambridge, MA: MIT Press.

Yore, L.D. & Shymansky, J.A., (1991). Reading in Science: Developing an operational concephon to guide instruction. Journal of Science Teacher Educadon, 2, 29-36.

Yore, L.D., Holliday, W.G. & Alvermann, D.E. (Eds., 1994) Special Issue: The reading-science learning-writing connecdon. Journal of Research in Science Teaching, 31, 873-1073.

Appendix A

Annotated Bibliography

Articles on Reading in Science

Breger,D.C. (1995). Theinquiry paper. Science Scope. 18(11). 27-32.

Breger discusses using inquiry papers, short weekly papers based on independent readings, to help students understand what they have read. In wridng these papers, students learn to organize and respond to sciendf~c text as well as learning skills that promote life-long learning. Breger explains that modeling the process for the students is necessary, creadng first a reading log, leading to an inquiry paper. A scoring rubric is provided for the assessment of the inquiry papers. As well, a list of sources on which students can base their papers is included.

Casteel, C.P., & Isom, B.A. (1994). Reciprocal processes in science and literacy learning. The Reading Teacher. 47(7). 538-544.

Casteel and Isom examine the parallel processes at work between literacy and science. They maintain that many of the process skills inherent in literacy are also an integral part of science and that these similarities can be used to help students in their learning. The authors also point out the value of using literature in the science program to make the unfamiliar more familiar. As well, Casteel and Isom advocate having students write and reflect about their experiences in science in order to foster further learning and understanding.

Center for Applied Linguistics. (1993). Integrating math and science with language instruction. Washington, DC: Author.

This document describes a program established by the Center for Applied Linguistics to improve math and science education for language minority students. To do this, two inservice training sessions were initiated for a number of classroom teachers. The goals of the in-services were to introduce teachers to the communicative approach to math and science, to develop instructional materials which aid in the integration of these subjects, to develop appropriate instructional and assessment practices, and to train teachers to train others in these methods. According to this report, the program was successful in attaining these goals.

Charron, E. & De Onis, A. (1993). More complementary than contrary. Science Activities. 30 (1). 13-17.

Charron and De Onis suggested that the gap between teachers who teach a "read the chapter and answer the questions" science lesson, and those who provide hands-on experiences is narrowing. A re-examination of the role of reading in science, and the need to include real-life experiences are two reasons for this changing view. Teachers are realizing that children need to create their own ideas about new concepts through self-exploration. An integrated teaching approach has also given teachers more time to facilitate this type of learning. Charron and De Onis believed that reading cannot take the place of doing science, but that the use of multiple information sources enhances learning. Cha~Ton and De Onis discussed how two teachers combine their interests to develop collaboratively a four step program that includes brainstorming sessions, activities, and reading. Both teachers believed that science should be taught using an equal combinadon of reading and doing and not used in isolation.

Drake, S.M., Hemphill, B. & Chappel, R. (1996) A novel approach. Science Teacher. 63 (7), 36-39.

This article describes how a grade nine class connected the novel Ring Rise, Ring Set to science. The novel had a heavy science content which the teacher used to pique students curiosity. The question asked was: were the scientific concepts encountered in the novel just science fiction or sound scientif~c thinking? This central issue served as a springboard for inquiry. The students went through several different scientif~c experiments to explore science and science-like ideas. The authors claim that the scientific content resembled a traditional ninth-grade program but in this approach the content was set in a more relevant context and therefore sparked the students' curiosity.

Eggerton, S. (1996). Balancing science and sentiment: The portrayal of nature and the environment in children's literature. Science and Children. 33(6). 20-23.

Eggerton examines the on-going controversy of scientific accuracy versus sentiment in children's literature. There are those who argue that imagination and real world overlapping create for children curiosity and interest. However, others argue that this overlap leads to the development of misconceptions in children's thinking. Eggerton explains that critical assessments must be made when choosing books on nature and the environment. Furthermore, it is essential that real life connections are made when using literature.

Farris, P.J. & Fuhler, C.J. (1994). Developing social studies concepts through picture books. The Reading Teacher. 47(5). 380-387.

In their article, Farris and Fuhler advocate the use of picture books in the classroom to teach concepts to students. They explain that picture books add detailed information which is lacking in many tradidonal textbooks. Picture books also lend themselves to the exploration of sensitive or controversial issues. Furthermore, picture books provoke curiosity and questions from students. Picture books can be used to make the abstract more real to students. The authors provide more in depth analysis of how picture books can be used in each of the following areas: anthropology, geography, history, and sociology.

Huber, R.A.& Walker, B.L. (1996). Science reading dos and don'ts. Science Scope. 20(1), 22-23.

Huber and Waker suggest that students must read about science in order to gain more information in addition to doing science. They explain that this provides the opportunity to teach students about science as well as improve their science reading skills. They provide a list of suggestions that can help science teachers support their students' growth in science knowledge and as readers. The list consists of the dos and don'ts involved when teaching science reading skills that promote a positive self-concept, attitude toward science reading and strategic approach to science reading.

Mayer, D.A. (1995). How can we best use children's literature in teaching science concepts? Science and Children. 32 (6). 16-19.

Mayer examines the use of children's literature in science programs. Using a variety of literature which is used in teaching science, the author set out to determine what students learn from the use of fiction (a checklist was developed to determine the suitability of the book). In the study, Mayer discovered that fiction may interfere with the acquisition of knowledge. It was further expressed that when choosing literature in the classroom, care should be taken to ensure accuracy of information in both the text and the illustrations to reduce possible misconception which may ensue.

Olson, M.W. & Gee, T.C. (1991). Content reading instruction in the primary grades: Perceptions and strategies. The Reading Teacher. 45(4). 298-307.

This article examines the need for young children to develop proficiency with expository texts, even in the primary grades. Having completed a survey, Olson and Gee share commonly recommended practices of primary teachers for content reading and also suggest specific strategies which are accompanied with examples to illustrate them. These strategies include: semantic mapping, KWL (what I know, what I want to learn, what I have learned), concrete manipulatives, expository paragraph frames, group summarizing, and visual imagery.

Schumm, J.S., Vaughn, S., & Leavell, A.G. (1994). Planning pyramid: A framework for planning for diverse student needs during content area instruction. The Reading Teacher. 47(8). 608-615.

The authors explain a framework for planning content area: a planning pyramid. The pyramid allows for inclusionary instruction for children with a broad range of abilities. The three degrees of learning examined are: what all student should know, what most but not all students will learn, and what some students will learn. The five points of entry described are: student, teacher, instructional practices, topic, and context. An example, using simple machines, is provided to illustrate the planning pyramid.

## Current Articles on Writing in Science

Clidas, J. (1996). Personal plot journals. Science and Children. 33(6), 22-25.

In this article Clidas describes how she organized and implemented 3m by 3m environmental study areas for her fourth-grade class. She goes on to describe the journals her students kept while visiting their plots twice monthly. These journals supported her students' science inquiry and learning and documented change over time. The field journals encourage her students to write like scientists, which in turn encourage them to observe, and think like scientists.

Ediger, M. (1994/1995). Writing in the science curriculum. Catalyst. 38(2). 36-41.

Ediger strongly advocates the use of writing in the science curriculum. He explains that clear communication of thoughts and ideas is imperative. As well, he demonstrates that writing does, in fact, aid students in learning and reflecting. Ediger recommends writing be used in the following forms: experience charts, outlining content, experiments, book reports, journals, diaries, and logs in order to provide optimal learning and understanding for students.

Johnson, T, Hawe, M. & Burkimar, J. (1995/1996). Augmentation: Extending ideas in report writing. Prime Areas. 38(3), 41-45.

Johnson, Hawe and Burkimar advocate the augmentation of a core text as a way for students to write reports. To augment a core text the students take a normal text and surround it with factual and fictional information. The original text is referred to as the core text. The additions represent the augmentation. They claim that by using augmentation, instead of copying, there is a significant increase in the quality of children's engagement and understanding of the source materials, and their written reports. These important cognitive activides happen because augmentation requires transformation of information and ideas encountered in the text. Augmentation also gives the students experience in writing expository texts. Johnson and Hawe give clear example of students' augmented reports, and how they are done in a classroom setting.

Ogens, E.M. (1996). The write stuff. Science Scope. 20(1), 15-17.

Ogens examines the use of journal writing in science class in dhis article. She describes how she uses journals in her classroom which include: to close a unit d~rough summary of ideas learned, setting goals, recording progress, and posing further questions. She also uses journal writing to determine the level of understanding of dhe concepts taught and to help her identify dhe areas chat need more clarification. As well, Ogens advocates journals as an invaluable instrument for promoting student-teacher dialogue -- conduit for learning.

Reif, R.Ji& Rauch, K. (1994). Science in their own words. Science and Children. 31(4).

Reif and Rauch oudine the value of students creating their own science books. This activity allows students to design, to write, and to illustrate d~eir own books, making science learning relevant to dhem. Students are able to share their books with dheir class and widh ocher students in the school. It is also explained chat this project is ideal as it can be adapted to the level at which the children are working. The audhors suggest d~ree formats dhe books may take: alphabet book, concept book, or science narrative. The further offer a variety of suggestions for illustration.

Rillero, P., Zambo, R., Cleland, J., & Ryan, J. (1996). Write from the start: Writing to learn science. Science Scope. 19(7). 30-32.

In dhis article, dhe authors advocate using dhe first few minutes of class for an activity called "Write Now." Students are asked to respond to a "quasar question"--powerful, open-ended questions which foster reflection and understanding. The teacher can use the questions as a form of daily assessment as well, assessing conceptual knowledge and misconceptions. The class can share responses and a discussion may develop from dhe varying viewpoints. The authors have provided examples of quasar questions and a variety of classroom strategies for using them.

Ryan, J., Rillero, P., Cleland, J., & Zambo, R. (1996). Writing to learn math and science. Teaching K-8. 27(1), 78-81.

The "Write Now" approach is a wridng to learn madh and science program [also see Science Scope, 19 (7)]. This is a warm-up approach which includes using an open-ended question posted in the front of the room upon dhe students arrival. The students answer the question by elaborating on what they learned in the previous days' lesson. This approach provides the teacher with a chance to see whether dhe students have understood the lesson from the previous day and to assess other prior knowledge related to the topic. The article further explains dhe types of science and math questions that work for this approach, and they claim that open-ended questions work dhe best.

Scarnati, J.T. & Weller, C.J. (1992). Write stuf£ Science and Children. 30(4). 28-29.

Scarnati and Weller advocate dhe integration of language arts into science. The audhors suggest chat narration, description, explanation, and persuasion are dhe four basic methods of writing. These should be a student's "main purpose in writing" rather than watching for errors, such as "misspellings, grammatical errors, and messy penmanship." Scarnati and Weller believed that there is "no better subject in which to practice these skills than science." By reporting on science activities, and keeping observations, students are in a situation where a need for different writing form exists. "Integrating science and language arts is easy to do as long as you keep in mind the four purposes for writing and recognize the relationship between writing and science inquiry skills. "

Articles on Integrated Reading and Writing in Science

Jaegar, M., Lauritzen, C. & Davenport, M.R. (1996). Integrating curriculum. The Reading Teacher. 50(1), 64-66.

The authors describe an integrated approach to the study of Hot Lake: a local hot springs site with old buildings and ponds. This mysterious environment with steamy waters, ghosts haunting the legendary spa provide a high motivation and interesting focus for experimentation. The students pursued the discipline of science, acted as engineers, and explored folklore and history in this study. The authors also explain the idea that teachers and students who have an understanding of the nature of these disciplines can further use this understanding as a prism for examining contexts, generating inquires, and determining explorations. The oral and print language arts are essential in the construction of understanding and in the sharing of ideas.

Lozauskas, D. & Barell, J. (1992). Reflective reading. The Science Teacher. 59(8). 42-45.

Lozauskas and Barell encourage the use of a "thinking journal" in the science classroom wherein students write their thoughts while they read science materials or perform science experiments. It is important for the teacher to model how to write in these journals using a "think aloud" technique. The authors give a list of "starters" for the journal entries. They further explain the usefulness of journals in the insight they can give regarding the students thought processes and as a means of communicating through a running dialogue.

O'Mallan, R.P., Foley, C.L., & Lewis, C.D. (1993). Effects of the guided reading procedure on fifth graders' summary writing and comprehension of science text. Reading Improvement. 30(4). 194-201.

The authors of this article examine the use of the Guided Reading Procedure (GRP) in writing summaries. Two groups of students participated: the control group was given a traditional science program while the experimental group practiced GRP through a process of gradual release. Through examination of products, including a pre and post test, it was determined that students may initially struggle with comprehension when first learning the GRP strategy; however, it is speculated that this lessens with familiarity. Summary writing improved-evaluators saw increased paraphrasing and decreased reproductions in the students' writing.

Schroder, G. (1996) The elements of story writing: using picturebooks to learn about the elements of chemistry. Language Arts. 73, 412-418.

In this article Schroder writes about how her grade six class wrote and illustrated picturebooks for younger children to help make abstract and difficult science concepts more understandable. Schroder talks about each step of her project which includes taking students through: research, modelling, developing a plan of action, drafting, ffnal revision and editing, and sharing the ffnished product: publishing. Schroder claims picturebooks were the natural bridge that made the study of elements meaningful to sixth grade students.

Go back to 1997 AETS Conference Proceedings

Date of last revision/update : Oct 2, 1997